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THE

Psychological Bulletin

GENERAL REVIEWS AND SUMMARIES

RECENT CONTRIBUTIONS TO THE PHYSIOLOGY OF THE AUTONOMIC NERVOUS SYSTEM

BY F. W. CARPENTER

Trinity College

The Nervous Mechanism of the Alimentary Canal.—The physiological study of the nervous mechanism of the stomach has been continued during the last two years by A. J. Carlson and his co-workers. Carlson and Braafladt (15) report experiments which afford evidence that the normal gastric mucosa is devoid of pain and tactile sensibility, but contains protopathic heat and cold nerve endings responsive to extremes of temperature. These endings are, however, more abundant and more readily stimulated in the pharynx and œsophagus. The authors reiterate their belief in a qualitative difference between hunger and appetite. Hunger they define as a complex of kinesthetic sensation (due to tension) and pain, while the term appetite is applied to a pleasanter, milder sensation turning one's thoughts to food in pleasurable anticipation. Their experiments indicate that these sensations may be called forth by the stimulation of entirely distinct nerve endings. Hunger, as has been repeatedly shown, is initiated in the normal empty stomach by strong contractions of its walls, and cannot be produced by any form of direct stimulation of the nerve endings in the gastric mucosa. The sensation of appetite, on the other hand, follows the excitation of the mucosa by chemical and possibly also by mechanical means. For example, appetite is experienced when such substances as hot or cold water, weak acids or weak alcohol are introduced through a tube into the stomach so as to avoid stimulation of

nerve endings in the mouth and œsophagus, which, under normal conditions, play a large part in bringing about the sensation, and are especially concerned in the memory factor. The authors believe that the sensation of fullness after eating is due to the tension exerted from within on the circular muscle fibers of the stomach following a tonus relaxation of these fibers. They find that the stimulation of the gastric mucosa with hot or cold water causes vasoconstriction in the arm if the subject is awake, but not if he is asleep. Changes in vasomotor tonus are, therefore, attributed to the influence of conscious cerebral processes induced by the gastric activity. The reflex excitability of the spinal cord is increased by stimulation of the gastric mucosa, much as it is by the hunger contractions of the empty stomach.

That hunger contractions are simply augmented peristaltic contractions is the view of Rogers (44) and Rogers and Hardt (47). Studies of the latter on man and dog show that the stomach during normal digestion exhibits a slow tonus rhythm which becomes more vigorous as the stomach empties itself, and finally gives rise to the periodic hunger pangs. Excitement, interest, worry, or any strong psychic influences immediately inhibit this rhythm. "Psychic inhibition" appears, however, to play an unimportant rôle in the control of the hunger mechanism in such stolid animals as guinea-pigs (King and Connet, 27). The stomach contractions in these animals proceed with regularity in spite of noises, voluntary movements, etc. But in decerebrate guinea pigs the contractions show a marked increase in rate, which seems to indicate that a certain degree of inhibitory control is removed with the destruction of the cerebral cortex, and also that the positive (excitatory) influence of the brain on stomach motility originates below the cerebrum.

From observations on a sleeping dog Luckhardt (31) concludes that the cerebral activity associated with dreaming greatly diminishes the hunger contractions of the empty stomach, which during deep and apparently dreamless sleep occur with regularity and vigor. The author assumes that movements of the limbs, tail and muscles of the face during sleep give evidence that a dog is actually dreaming.

Rogers (45 and 46) reports that the crop of pigeons deprived of food exhibits hypermotility, and that this vigorous activity is checked by "any conditions causing fear or surprise," and also by lesions of the cerebellum and membranous labyrinth, as well as by

the taking of food or water. In decerebrate birds no inhibitory reactions were obtained from non-painful external stimuli, but such reactions followed intrinsic painful stimuli or injury of the equilibratory apparatus. Hunger, thirst and sometimes intestinal impulses aroused the decerebrate pigeons to restlessness.

Brunemeier and Carlson (4) find that gastric hunger contractions in dogs may be inhibited for varying periods by introducing food or other materials through a fistula into the small intestine. The inhibition takes place primarily through reflexes involving the vagi, the central nervous system and the splanchnics, although the local enteric nervous apparatus plays a minor part in the reaction.

Comparative studies of the hunger mechanism of the frog and turtle were made by Patterson (34) and (35). That of the frog appears to be relatively simple and automatic. Hunger movements are not affected by the removal of the cerebral hemispheres. Differences in the irritability and latent period in various regions of the stomach wall of the frog and rabbit were investigated by Alvarez (1).

The secretion of gastric juice in man is, according to Carlson (13), a continuous process not dependent upon direct nervous stimuli, but probably maintained by the secretory tonus of the vagus nerves, and possibly also by the action of secretagogues yielded by the autodigestion of the gastric juice itself. Such psychic forms of "stimulation" as seeing, smelling and even merely thinking of palatable foods usually produce only a slight and very transitory increase in the secretion of gastric juice.

Carlson (14) brings together in a single volume entitled, *Control of Hunger in Health and Disease*, much recently acquired information concerning the functioning of the nervous mechanism of the digestive organs.

Internal Secretions and the Autonomic System.—Physiologists continue to be interested in the relation between emotional states and the secretion by the adrenal glands of epinephrin, which, circulating through the body in the blood stream, stimulates the sympathetic nervous system, and thus produces widespread results, all of which tend to prepare the body for action. Stewart and Rogoff (51) criticise Elliott's conclusion that "fright" in cats, induced by the administration of morphine or β-tetrahydronapthylamine, causes the diminution of the store of epinephrin observed in the adrenals after such treatment. They give evidence for regarding the effect on the adrenals as due to some action of the drug other than the hypothetical emotional disturbance. Hartman

(22) finds that the same dose of dilute adrenalin causes dilatation of the peripheral arteries and constriction of the splanchnic arteries. This differential response of blood vessels to adrenalin is in accordance with their functional use in times of excitement. The voluntary muscles are thus insured an abundant blood supply for their most efficient action. When adrenalin is injected intravenously into dogs, Hoskins, Gunning and Berry (25) report active dilatation of the blood vessels of the limb muscles and constriction of the cutaneous vessels. Hoskins (23) removed portions of the adrenal tissue of dogs, and noted that the partial adrenal deficiency resulted in a depression of the irritability of the sympathetic nervous system proper. Hoskins and Rowley (26) found, contrary to their expectations, that infusions of adrenalin in anesthetized dogs failed to augment vasomotor irritability or facilitate the transmission of vasomotor impulses. On the contrary vasomotor irritability was, in most cases, lessened. The authors think it probable that under ordinary conditions epinephrin does not exist in the circulating blood at all. Under conditions of special stress, however, when the adrenal glands are discharging relatively large amounts of their secretion into the blood, the depressing influence as compared with the stimulating effect would be slight and probably negligible. Gley and Quinquand (21) were unable to demonstrate any direct relation between the adrenal secretion and the vasomotor function of the splanchnic nerves. Intravenous injections of physiological amounts of adrenalin in dogs has a two-fold effect on the heart rate according to Meek and Eyster (33). The adrenalin accelerates the heart by direct stimulation and at the same time inhibits it reflexly through the vagus. The net result of this balanced mechanism is always, under ordinary conditions, a decrease in the heart rate. But in exercise pushed to an extreme, when the body is in great physiological need, the accelerating effect of the adrenalin dominates.

Kuroda and Kuno (28) report that injections of adrenalin decrease the excitability of the vagus. Richards and Wood (43) carried out experiments on rabbits which showed that stimulation of the depressor nerve results in a decrease of the rate of discharge of epinephrin from the adrenal gland. The mechanism of adrenal secretion appears, therefore, to be involved not only in pressor but also in depressor reflexes. The inhibition of secretory activity is due to nervous influences exerted directly upon the secretory structures, and not to changes in the blood flow through the gland. The

epinephric content of the blood was measured in dogs by Bedford and Jackson (3) under conditions of low blood pressure and "shock." They interpreted the data obtained to mean that under such conditions there is an increased activity of the adrenal glands.

Cannon and Cattell (11 and 12) have devised a method of using electrical responses as an index of glandular action. By means of this they have determined that the thyroid gland is innervated by fibers belonging to the sympathetic (thoracico-lumbar) and not to the cranial division of the autonomic system. These fibers are truly secretory in function; the effects are not brought about indirectly through alteration of the blood supply. The authors also find that epinephrin, liberated from the adrenals into the circulating blood by nervous stimulation, evokes secretory activity in the thyroid. It would appear, then, that in times of excitement the epinephrin discharged through "emotional stimulation" of the sympathetic nerves, includes among its various effects the excitation of the thyroid gland, the augmented secretion of which may play an emergency function in regulating the metabolism of the body under the changed conditions. The results of Cannon and Cattell are confirmed by Levy (30), who adds the observation that the thyroid secretion renders more excitable those sympathetic structures which are acted on by epinephrin in raising arterial pressure.

The stimulating action on the autonomic system of the internal secretions of glands other than the adrenals and thyroid has been studied by a number of workers. Shamoff (49) finds that extract of the posterior lobe of the pituitary body inhibits the rhythmic contractions of the isolated intestinal loop, presumably by affecting, like adrenalin, the sympathetic nerves (inhibitory) supplying the loop. Extract of the pituitary gland was observed by Waddell (53) to have a depressing effect on both the circular and longitudinal musculature of the frog's œsophagus. The secretory discharge of the gland can be called forth by stimulating the superior cervical ganglion of the sympathetic trunk (Shamoff, 50). Injections of extract of the pineal gland bring about in growing rabbits, according to Del Priore (17), a marked lowering of the blood pressure. The internal secretions of the testis are believed by Wheelon and Shipley (54) to have a direct effect upon the sympathetic nervous system. Their experiments afford evidence that castration results in a depressed activity of the sympathetic mechanism, while restitution of the testicular tissue by the method of implantation tends to lift the depression, and at least partially to restore normal activity.

The relation between pancreas deficiency and vasomotor irritability was studied by Hoskins and Gunning (24), whose conclusion is that there is little evidence to support the theory that the pancreas normally exerts, through the action of its hormones, a depressing influence upon the sympathetic. Streuli (52) discusses at length the action of the various internal secretions upon structures under autonomic control. Schafir (48) considers as still open the question of the influence of calcium ions in the circulation upon the irritability of the autonomic system, but is convinced that calcium deficiency has a depressing effect.

The Vasomotor Mechanism.—On the basis of experiments with curare Porter (37) argues for the existence in the medulla of separate, although related, centers for vasotonus and vasoreflexes. Porter and Turner (38) in a later paper describe vasomotor phenomena, following the injection of certain doses of alcohol, which they believe could not occur if the central vasotonic and vasoreflex mechanisms were identical. Martin and Stiles (32) are of the opinion that depressor and pressor influences act upon different parts of the central mechanism which controls reflexly vasomotor activities.

New evidence of the presence of a chief vasoconstrictor center in the medulla is presented by Ranson (40), who traces the course of the afferent and efferent limbs of the pressor reflex arc in the cord. The former is described as following the apex of the posterior horn, the latter as lying in the lateral or ventral funiculus. Ranson and Billingsley (41 and 42) report further studies on the vasomotor reflex arcs. The afferent spinal path for depressor reflexes is placed in the lateral funiculus. It is pointed out that a separate vasodilator center may exist, and its probable position in the floor of the fourth ventricle is given with some precision.

Burton-Opitz (5) finds by experimental methods that the nerve fibers which innervate the blood vessels of the central duodenum ascend from the cœliac ganglion by way of the plexus gastro-duodenalis and the plexus pancreatico-duodenalis. The same author (6) questions the validity of Mall's conclusion that the portal vein is innervated by venomotor nerves. In a third paper (7) he gives reasons for regarding the vasomotor innervation of the kidneys as unilateral, the direct vasomotor influence of the splanchnic nerve of one side of the body being restricted to the kidney of that side. Burton-Opitz and Edwards (9) obtained in the dog experimental results which indicate that the sympathetic trunk embraces vasoconstrictor fibers governing the vascularity of parts not included

within the distribution of the greater and lesser splanchnic nerves. The greater splancnnic is regarded by Burton-Opitz (8) as the depressor for the abdominal organs, since it serves as an afferent path for nervous impulses which bring about a general vasodilatation. Vasomotor nerves are present in the bone marrow according to Drinker and Drinker (18). These nerves cause vasoconstriction when stimulated electrically or by the injection of adrenalin.

The Vagus Nerve.—Various functions of the vagus nerve have been recent objects of investigation. Eiger (19) has demonstrated its direct secretory influence on the cells of the liver. Further details of the inhibition of pancreatic secretion through stimulation of the vagus are given by Anrep (2). The blocking of the discharge is said to be due to constriction of the pancreatic ducts or to retention of the juice in the glandular cells which secrete it. The accumulation of the secretion causes an evident dilatation of the gland. Pearce and Carter (36) were unable to detect any change in the oxygen consumption of the kidney during stimulation of the vagus fibers supplying that organ. They regard this as evidence against the supposed existence of renal secretory fibers in the vagus. According to Ranson (39) the nerve fibers which subserve the protopathic temperature sense of the gastric mucosa are to be recognized in the non-myelinated afferent fibers of the vagus distributed to the stomach. The cell-bodies of these fibers are situated in the ganglion nodosum. It has already been noted that Kuroda and Kuno (28) find the excitability of the vagus lessened by injections of adrenalin.

General.—Langley (29) gives a sketch of the progress of discovery in the field of the autonomic nervous system during the eighteenth century. In his book entitled *Bodily Changes in Pain, Hunger, Fear and Rage*, Cannon (10) describes and discusses at length his recent researches into the physiological function of emotional excitement. He sets forth his views regarding the effect of the emotions through the autonomic system on digestion and adrenal activity, and traces the influence of the augmented adrenal secretion on muscular fatigue, the mobilization of blood sugar, and the coagulation time of the blood. He emphasizes the utility of the bodily changes brought about by pain and great emotion, and closes with a timely chapter on "alternative satisfactions for the fighting emotions." *The Origin and Nature of the Emotions* by Crile (16) is a volume comprising a number of articles which deal with various aspects of the subjects from the standpoint of a medical man with clinical experience, a mechanistic outlook on life, and a

lively interest in the phylogenetic interpretation of psychological and pathological phenomena. The monograph by Gaskell (**20**) on *The Involuntary Nervous System* has already received notice in this journal.

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CEREBELLUM AND BRAIN-STEM[1]

BY ROSWELL P. ANGIER

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The book by André-Thomas and Durupt (1) was not accessible to the reviewer but is referred to in a footnote by Black (3) as presenting the results of the researches of the authors on cerebellar localization on dogs and monkeys, "together with an interesting and detailed review of the subject in all its phases and an extended bibliography." Black (3) gives a brief review of recent work tending to support the hypothesis, to which the late Max Rothmann gave much attention, that there exists specific cerebellar cortical localization of function analogous to that of the cerebral cortex. Meyers (12) feels it to be established that the traditional forced movements, etc., of animals subjected to cerebellar operation are not cerebellar in origin but are due, rather, to the inclusion of the

[1] For the last previous review on this topic see the Bulletin, 1915, **12**, 145–148.

vestibular complex or its oculomotor tracts. The phenomena of true cerebellar genesis he takes to be ataxia and tremor, since there are constant and marked symptoms found in lesions limited to the lateral lobes of the cerebellum without involvement of the vestibular complex. He has furthermore never been convinced of the existence of hypotonia in cerebellar lesions. However all this may be, Meyer's own experimental work, based on the fact that active tissue is invariably electrically negative to resting tissue, offers several points of interest. First, he established the fact that after removal of one of the lobes of the cerebellum the motor nerves (the sciatic or the ulnar) on the side of the lesion were negative to those of the uninjured side. Secondly, in animals with one lateral cerebellar lobe and the contralateral motor area of the cerebrum removed, he found no galvanometric deflections whatever. Control animals, however, with the contralateral cerebral motor area intact, but with large other cerebral areas removed, showed the characteristic negative variation identically the same as in the earlier animals in which a cerebellar lesion alone had been produced. Meyers concludes, therefore, that the cerebellum has no direct motor effect on the musculature but acts as an inhibitory organ on the cerebral motor areas. When, for instance, one lateral cerebellar lobe was removed and the contralateral cerebral motor area left intact, the muscular reactions on the side contralateral to the motor area exhibited all the usual signs of hyperexcitability or of the release of inhibitions—excessive, forcible and unchecked movements, overshooting the mark. The phenomena usually ascribed to cerebellar deficiency are thus really phenomena of hyperactivity of cerebral motor areas, paracerebellar nuclei in the medulla, etc. The cerebellum is a purely afferent mechanism. These are interesting hypotheses but so variant from the usual conception of cerebellar function as to require further experimentation and control. In a later article Meyers (13) argues that if his previous findings are valid the problem of cerebellar localization should be studied through the medium of the motor cortex of the cerebrum. He accordingly subjected certain lobules of the cerebellum of the cat to small circumscribed lesions and, after good recovery, injected small amounts of oil of absinthe into the external jugular vein. It is well known that in normal animals such treatment produces marked convulsions simultaneously in all the muscles of the body. In the case of the cats with operative cerebellar lesions Meyers found that in certain muscles—in general those functionally related,

according to Bolk's theory of cerebellar localization, with the lobules subjected to lesion—there appeared either a greater intensity of convulsion than in the other muscles, or that such muscles alone showed convulsions, the rest of the body being quiescent. Cerebellar functions are thus "differentiated for the various muscle groups of the body, indirectly, by being primarily related through its various lobules to the various motor centers in the cerebrum and the tonus centers in the medulla." Rothmann (15) briefly reports certain experimental results on cerebellar localization in the dog. In one animal the lesion was in the anterior part of the posterior median lobe and after eleven months the only symptom noticed was a "Neinschütteln des Kopfes." In another animal, with total removal of the cortex of the vermis, with hemispheres and nuclei intact, ataxia of the head, trunk, and extremities was pronounced during the three and a half months that the dog lived, and the bark reflex was absent. Postural disturbances of the extremities were, however, not in evidence; these are to be referred, in part at least, to the hemispheres themselves. Bikeles and Zbyszewski (2), on applying from 2 per cent. to 5 per cent. solution of cocaine to the motor area of the cerebrum, found marked decrease in sensitivity of response to electrical stimulation. The same applications to the crus secundum lobi ansiformis of the cerebellum had little or no effect at all on its responses.

On the functions of the brain-stem the more recent work of the indefatigable Brown has some bearing. In one series of experiments (4) he demonstrated that stimulation of points at a cross section of the mid-brain of a decerebrate chimpanzee just anterior to the superior colliculi and involving the red nucleus evoked reactions similar to those already described for monkeys,[2] *i. e.*, postural contraction of flexors of ipsilateral arm and of extensors of contralateral arm. In the chimpanzee, however, certain variations were noticed, *e. g.*, at times the ipsilateral effect was chiefly extension and the contralateral chiefly flexion. The results are puzzling to the author and may conceivably be due either to a spread of the stimulus from ipsi- to contralateral area (or vice versa), or to a double action of each red nucleus, its flexion effect at times masking its extensor effect, or the reverse. A second investigation (5) offers some evidence that states of *plastic* postural flexion (allowing passive alteration of the state of contraction—opposed to rigid flexion) met with in experimentation on cerebral motor areas is really due to the action

[2] See review in BULLETIN, 1915, 12, 146.

of the red nucleus. In another experiment (6) on the same chimpanzee mentioned above the stimulation of certain circumscribed areas of structures probably lying in or near the caudal pole of the thalamus yielded alterations in breathing and blood pressure characteristic, in the intact animal, of various emotional states—"panting," "sighing," or "hollow" breathing and, particularly, the rapid "laughter" breathing. The experiment, says Brown, gives definite proof of the connection of the caudal pole of the optic thalamus with activities which condition reactions expressive of emotional states. In a further experiment (7) Brown secures primary facilitation (repeated stimulation of the same point producing progressive augmentation of the extent of muscular reaction) on stimulating (1) the gray matter of the cortical motor area, (2) the nerve-fibers of the cortico-spinal tract just below the cortex, (3) the same fibers lower down in the internal capsule and, (4) at the level of the midbrain. The question then arises whether this facilitating mechanism is located only in sub-cortical structures (the phenomena, when obtained by cortical stimulation, thus depending on its subcortical effects) or in both cortical and sub-cortical structures. That it lies at least sub-cortically the investigation amply proves. But it is also probable that primary facilitation occurs in the cortex itself. The author had previously (8) shown, namely, that secondary cortical facilitation (the augmenting, by repeated stimulation of a given cortical point, of the responsiveness of similar neighboring cortical points) has a cortical seat. This means, however, that the excitability of the secondary points is raised by repeated natural stimuli, although the source of these stimuli is in the neighboring primary point. Hence there is every reason to suppose that primary facilitation may also have a cortical as well as a sub-cortical location. The proof does not appear quite convincing, but is interesting.

Ranson (14) adduces certain experimental evidence (on cats) to show that there is a vasoconstrictor center somewhere in the brain, the pressor reflex-arc not being complete, therefore, within the cord—a matter hitherto in doubt. Miller and Bowman (11) report an investigation which serves to locate the cardio-inhibitory center in the dorsal vagus nucleus—a result in harmony with previous histological findings of Kohnstamm and of van Gehuchten and Molhant.

Articles by Grey (9, 10) and Schaller (16) were not accessible to the reviewer.

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REFLEX MECHANISMS AND THE PHYSIOLOGY OF NERVE AND MUSCLE

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The greatly reduced investigation on these topics in 1916 seems to yield but three papers on reflex mechanisms. Ranson and Billingsley (**12**) identify the cutaneous "protopathic" system of Head with certain unmyelenated fibers of the posterior spinal roots. In

1912 Ranson published his discovery of unmyelenated fibers in the dorsal roots. These are mostly cutaneous nerves, and they practically all enter the cord in bundles which lie laterally to the myelenated fibers of the same root. The former are called by Ranson the "lateral division" of the dorsal root. A much smaller number of myelenated fibers is found also in this lateral division. All the neurones of the lateral division run up or down, in Lissauer's tract, a very short distance—usually less than a segment. "That is to say, these fibers run into the gray matter at or near the level at which they enter the cord. Their intraspinal course suggests at once that they are the fibers of pain and temperature sensations, since it is known that the afferent impulses underlying these sensations pass through the gray matter as soon as they reach the cord." The authors' experiments consist in studying the vasomotor and other responses to pain and temperature stimulation of the skin, in cats in which either the lateral or the medial division of the posterior root has been cut. It is concluded that the myelenated fibers of the lateral division represent the epicritic, and the unmyelenated fibers the protopathic, afferent cutaneous systems of Head.

Brown contributes two more papers (3, 4) in his series of 1914–15. Apart from a study of motor responses elicitable by unipolar stimulation of the post-central convolution (in 4), both papers deal mainly with primary and secondary facilitation. Repeated "subliminal or just liminal" stimulation of a point in the motor region will gradually raise its excitability ("primary facilitation"); and the excitability of neighboring cortical points is raised at the same time ("secondary facilitation"). This latter is due to stimulation of the underlying association fibers, and not merely to a spread of the electric current as such to the surrounding brain tissue (3). It seems not unlikely that facilitation is closely related to the psychologists' phenomenon of summation of sensation.

In the field of nerve and muscle physiology, Bethe (2) offers a general theory of irritability which is based on the phenomenon of capillary action. In this theory, which is explicitly proposed as an alternative to the Nernst theory, the "semi-permeable membrane" of Nernst is taken to be a fixed reticulum the perforations of which give rise, by capillarity, to exchanges between liquids on opposite sides of the network. One of the crucial statements is most safely quoted without translation: "*Durch Adsorption von Ionen am Material der Porenwände (oder auch durch Komplexbildung) wird*

hier im Prinzip dasselbe erreicht wie dort [the Nernst theory], *nämlich eine Behinderung in der Beweglichkeit gewisser Ionen*" (p. 153). Of the effects which "capillary" action will produce Bethe lays most stress on changes of H-ion concentration: "It seems at least probable that increase or decrease of the H-ion concentration directly modifies the irritability of living tissue, and in such wise that an increase excites, or increases the irritability, a decrease reduces the same" (p. 171). Electrical, mechanical, and chemical modes of stimulation are discussed from this point of view, and although the author concedes that at present the capillary theory can be given no mathematical formulation, he adduces in support of it several lines of evidence; such, as for instance, the reversibility of galvanotactic response in microörganisms by variation of the salt concentration in which they are placed. There is a somewhat interesting criticism of the Nernst theory (pp. 148–155). In connection with either theory it is perhaps worth while to consider whether it sufficiently takes account of the fact that stimulation is, in muscle certainly and in nerve probably, a process of *release* of stored chemical energy.

Lillie (9) has added a third section to his study of the theory of conduction in irritable tissues, in which he further explains "the theory that the transmission of the excitation-state from the immediate site of activity to the adjoining resting areas is dependent on an *electrical local action* of the same essential nature as that which is responsible for the etching or corrosion of non-homogeneous metallic surfaces (for example, of iron) in contact with an electrolyte solution: . . . this local circuit, having once originated, produces effects similar to those of any other electrical current upon the adjoining portions of the irritable element; at the still resting regions the direction of the current entering the cell-surface from the external medium is such as to cause local depolarization, an effect resulting, if sufficiently intense, in stimulation. This secondarily stimulated region produces similar effects at the region beyond; hence the excitation-effect *spreads*, . . . at a rate determined by the temperature, the composition of the medium, and the specific peculiarities of the tissue. . . . The changes associated with excitation (negativity and increased permeability) are rapidly and automatically reversed when the wave of excitation reaches any region of the element. Thus in the typical irritable element like nerve the local excitation-process is automatically self-limiting. The high velocity of transmission is apparently a function of high

irritability—*i. e.*, promptness and rapidity of local change, and great sensitivity to variations of surface-polarization—and its conditions have been discussed in the first paper of this series. With regard to the self-limiting characteristic, there is every indication that this is at bottom nothing but an expression of the well-known polar action of the electrical current upon such tissues—*i. e.*, inhibition where the current enters the element (at the anode of the electrodes from an external source of current), and stimulation where it leaves. . . . The current of the local active-inactive circuit has such a direction that at the original site of excitation the positive stream *enters* the cell-surface from the medium, while at adjoining regions (not yet excited) it leaves. . . . The precise metabolic basis of these changes cannot be indicated at present." The work of Lillie, like that of Lapicque and Hill, is partly based on the Nernst theory, and aims to extend the latter and to make it more precise.

The late Keith Lucas held the local excitatory process and the propagated disturbance, in nerve, to be distinct; and he believed that the former did not exhibit the refractory phase which is characteristic of the latter. From his latest investigation Adrian (1) concludes that during the absolute refractory period both processes (local excitation and conduction) are in abeyance, and that "the nerve regains its power to conduct impulses at the same moment at which it recovers its excitability to strong external stimuli. . . . This removes a possible objection to the theory that conduction is due to a spread of the excitatory process." The above-mentioned theory of Lillie seems to favor this latter view.

Forbes, McIntosh, and Sefton (6) state that "in all experiments with general anæsthesia it as found that muscular contraction in response to motor nerve stimulation remained vigorous at all depths of anæsthesia, even after respiration had ceased altogether." With direct stimulation of motor nerve, under extreme ether anæsthesia, they find that muscular contractions disappear slightly earlier than the action current. "The action current is probably a valid criterion of function" in nerve, and is probably an inseparable feature of the nervous impulse.

Cannon and Gruber (5) describe "wave-like variations in the height of contraction" which "are obtained from mammalian muscles under rhythmical and uniform stimulation." These are most pronounced in fresh and vigorous muscles; "they occur too soon to be the result of a fatigue process; . . . they gradually decrease in rate as fatigue approaches and the height of the muscular

contraction becomes low. . . . The muscle waves are observed in curarized or isolated or denervated muscles; in the body they do not coincide with waves of arterial pressure. They are, therefore, strictly of muscular origin."

Relatively slow waves of contraction can sometimes be seen travelling along a muscle fiber, and sometimes on arriving at the end they are reflected back again. These have been described by previous observers, under mechanical and electrical stimulation, sometimes under stimulation from the nerve, and in dying muscle. Langley (**8**) now describes such slow waves of contraction produced by chemical stimulation. The underlying metabolic process is obscure.

Münnich (**10**) has reviewed the various measurements of the rate of propagation of impulses along motor nerves, and has made new measurements of the same (cat, dog, man). In three dogs the mean measurements were 61, 85, and 88 meters per second. In man the means ranged between 66 and 69.3 m. per sec. These figures agree more closely with the early measurements of Helmholtz and Baxt (64.56 m.) and Alcock (66.8 m.) than with Piper's more recent figure (120 m.). In a somewhat complicated paper Pauli (**11**) reports that the demarcation current behaves, under the influence of cooling and warming, *alike* in nerve and in muscle. He ascribes the demarcation current, in both cases, to the presence in the injured portion of the tissue of "*elektromotorisch wirksame Elektrolyten.*"

Langley (**7**) has studied the loss of weight and atrophy of denervated muscle as affected by passive flections, or by condensor shocks, applied for 2½ hours daily for 30 days. "It is clear from the results . . . that neither electrical stimulation nor passive movement had any definite effect in preventing loss of weight" of the muscle. "It may fairly be concluded that the atrophy of denervated muscle is not due to the absence of contraction. . . . It does not however follow that stimulating denervated muscle may not have a slight beneficial effect." Langley believes that the atrophy which appears within one or two months after denervation is not a true atrophy of disuse.

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SPECIAL REVIEWS

Health and Disease: Their Determining Factors. R. I. Lee. Boston: Little, Brown, 1917. Pp. xv+378. $1.75.

Although the present work does not deal with psychology it is of interest to note that it shows the tendency to give to psychological matters more emphasis than is usually given in text-books dealing with hygiene, and this indicates a spreading appreciation of the importance of the mental factors in disease. In fact one chapter of the book deals with the hygiene of the mind, although it should be stated that this is only three pages in length and not more than one of those can strictly be called mental hygiene. Other chapters of interest to psychologists deal with heredity, with exercise and work, including sleep and dreams, with the effects of alcohol, tobacco, and the habit-forming drugs, and with light and its effects upon the eyes.

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Backward Children. A. Holmes. Indianapolis: Bobbs-Merrill, 1915. Pp. 241.

This book is a popular study of specific cases of backward children giving some idea of different types of backward children who are not feeble-minded, and urging the careful examination and training of these children. It is true, as the editor states, that the book is "particularly free from technical or professional terminology so that the layman can read it with ease," but surely it is not true that the "parent, teacher, medical inspector or clinician can use Dean Holmes' book in much the same way that a botanist, say, would use a key to the flower he is identifying and classifying." The author, indeed, contradicts this statement of the editor for he says (p. 138): "As soon as mental retardation is suspected, a diagnosis ought to be made by a specialist. . . . None but a specialist in mental retardation is fitted to make it."

In his first chapter, "Measuring rods for children," Dean Holmes gives examples of children measured by "individual standards" and by the "social standards in the home," and discusses the "more accurate standards,"—the pedagogical standards of age and grade and of progress in school, the standards of the playground and the Binet-Simon standard. Without having found any definite statement of the comparative value of the different standards, we are left with the impression that individual standards are useless, that home and school standards often give contradictory results, and that the Binet-Simon scale is often misleading, but that "not too much weight can . . . be given to the place secured by a child in his own world of unsupervised play."

The greater part of the book consists of descriptions of cases typical of different types of backwardness. The descriptions generally include personal appearance, behavior in school and at home, the causes and treatment of the backwardness. In spite of the emphasis laid upon the point in the first chapter, little or no mention is made of the "place secured by a child in his own world of unsupervised play" and no mention is made of results of Binet examinations. The standards used seem to be almost wholly pedagogical. Children are classed as temporarily and permanently backward. Cases are cited in which temporary backwardness was due to (1) physical defect, (2) a slow mind, (3) a concrete mind, (4) lack of interest in lessons, (5) badness, (6) environment, (7) lack of home training. Dean Holmes then goes on to discuss home training, discipline and feeding.

A chapter on "The clinical diagnosis of backward children" states the question to be solved not as "What is the child now?" but as "What will he be at puberty when all his mental faculties have reached their maturity?" A thorough examination is to include an oral examination concerning his pedagogical history, his personal history (capacities, moral character, diseases, etc.), his family history; a physical examination; and mental tests, both pedagogical and non-pedagogical (such as Binet tests) and a vague un-illustrated group of tests for specific defects in particular mental processes. The chapter concludes with a short discussion of feeble-mindedness.

In the following chapter the teacher is warned not to judge by external appearances, but to discover how much the child knows, in what his interest lies, to study his temperament, to find out how he "perceives, remembers, imagines, and reasons." The book closes with a discussion "The teacher and equipment for a special class." After a long description of a special class teacher who turned out better than was expected, we read of the attributes, temperament, training and experience required, and, then, a detailed list of suggested equipment.

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DISCUSSION

CEREBRAL ADAPTATION VS. CEREBRAL ORGANOLOGY

Over a hundred years have passed since the publication of Gall's system, and over fifty years have gone by since Broca reported his celebrated case of motor aphasia. Both of those contributions have had much to do with the formulation of the now widely accepted hypotheses regarding cerebral function, although it might be difficult to get the admission of the close relationship with Gall from those who hold to the simple current teachings. Several years ago I made an examination of the cerebral physiology contained in some of our widely used American text-books and monographs of psychology and physiology, which revealed to me the prevalence of an organology view, not entirely unlike that against which I have protested.[1] In most cases it was obvious that Sherrington's "Integrative Action of the Nervous System" (published in 1906) was known, but in some it was equally obvious that its

[1] "New Phrenology," *Science*, 1912, 35, 321–328.

lessons had not been understood. The cerebrum as a collection of spatially related conglomerates of cells and fibers, each conglomerate having a certain function (perhaps mental) is easily apprehended by the instructor and easily taught to the student. As a mechanism with interrelated parts it is not readily understood, because the mutual relations (anatomical and functional) of some of its parts are not known. This can best be understood by considering what I have been calling the "negative" facts, and we now have a number of such facts which must be given due attention. To some of these facts I have previously called attention,[2] but their importance warrants repetition. The latest is contained in a recent paper by Brown and Stewart which will be referred to below.[3]

The results of Vitzou[4] obtained in experimental destructions of the so-called visual cortex of the monkey's brain (temporary blindness but with eventual recovery of the ability to see) are first to be cited. Assuming that the destructions were complete, it is not possible to understand these recoveries from the standpoint of cerebral organology, for the cortex is looked at as a locus of certain physiological processes which give rise to or which are coincident with the mental states (sensations or perceptions). The second fact which may be cited is that of recovery of "voluntary" motor ability after the destruction of the so-called motor cortex or of the fiber connections. In a recent paper I have called attention to this fact,[5] for it was found that even though a paralysis had existed for a dozen years or more some functional return could be brought about. Some doubt may exist that in the cases which have recovered there has been an actual destruction of the motor cells or fibers, although the clinical conditions were those which have been found in cases of "organic" paralysis. Such a doubt cannot exist for experimental work on animals, some of which will be reported shortly,[6] in which the motor areas were destroyed by a thermo-cautery. In these animals the destructions were immediately followed by a typical hemiplegia which disappeared under suitable treatment within

[2] See pp. 19–21 of my monograph, *The Occipital Lobes*, Psychol. Monog., 1911, No. 56.

[3] T. G. Brown and R. M. Stewart, "On Disturbances of the Localization and Discrimination of Sensations in Cases of Cerebral Lesions, and on the Possibility of Recovery of these Functions After a Process of Training," *Brain*, 1916, **39**, 348–454.

[4] See p. 19, of the monograph cited, with references.

[5] Franz, Scheetz and Wilson, "The Possibility of Recovery of Function in Long-Standing Hemiplegia," *J. of Amer. Med. Assn.*, 1915, **65**, 2150–2154.

[6] Franz and Oden, "On Cerebral Motor Control: The Recovery from Experimentally Produced Hemiplegia," *Psychobiology*.

four weeks. In these cases, also, we were able to get recovery from a hemiplegia on the right side, and after producing a cortical hemiplegia on the left side we obtained a complete restitution of the function on that side. In these cases, therefore, the functional restitution was not brought about by the assumption of the function by the corresponding opposite hemisphere. The latter conclusion, namely, that when there is restitution of function this is brought about by the assumption of a bilateral control by the remaining normal corresponding area of the opposite hemisphere, is the favorite explanation of the functional return, or recovery, of speech ability in aphasics. In that class it has long been known that suitable training brings about an ability to understand (if the patient be a "sensory" aphasic) or an ability to vocalize (if the patient be a "motor" aphasic). Few careful studies of the course of reëducation of aphasics have been published,[7] but an investigation now in progress shows that the learning is very slow, much like that of an activity not previously acquired even in its elements.

To these facts which show that there is a possibility of recover of motor, visual, and speech functions after the destruction of those cerebral parts which are thought to be normally concerned in them, there is now added the work of Brown and Stewart on the recovery of the ability of tactile localization after the destruction of the post-central cortex. Their subject was a man who had been wounded in such a manner that his ability of localization had been much reduced or lost. At first the patient was aphasic and hemiplegic, and they began their experiments fourteen months after the accident, during which time the patient exhibited the abnormal condition of not being able to localize tactile stimuli when given to the right hand. The training consisted in touching a part, and telling the patient where he had been stimulated and getting him to pay attention to the conditions. Since previous tests had been made to determine the accuracy of his localization ability it was possible to determine after the period of training what improvement had taken place. In the words of the authors: "Marked improvement of the localization of tactile stimuli on the trained spots as compared with the accuracy of that localization on the same finger before the training, and with the accuracy of localization upon the other fingers after the training" indicates that there has been a functional recovery.

[7] See on this point my paper, "The Reëducation of an Aphasic," *J. of Phil., Psychol., &c.*, 1905, **2**, 589–597.

The collection of negative cases which is here made might be added to, but sufficient are cited to show that the destruction of a part of the cerebrum which is followed by an obvious defect does not mean that that part of the cerebrum is solely concerned with that function. The facts show that even though there be an abolition of function there is a possibility of recovery, or, to state the matter in other terms, that the loss of a certain function because of cerebral destruction does not indicate that the individual has not the functional capacity, if suitable conditions of stimulation are provided. This means that the motor cortex is not necessary for the execution of a voluntary movement, that the visual cortex is not necessary for vision, that the tactile cortex is not necessary for tactile discrimination, and that the speech cortex is not necessary for speech functions.

When these facts are admitted, as they must be admitted, the whole structure of cerebral organology breaks down. The histological localization of function which has been in vogue takes its true place as a histological differentiation of an anatomical nature, without the functional implications which have been assumed. The facts also indicate the necessity for a careful reinvestigation of many of the parts of the cerebrum especially by methods of destruction, and by the utilization of our knowledge and by the methods of habit formation. What appears to be most probable is that there is much more variability in the functions of different brains than has been admitted, and that there are mechanisms for the performance of various operations which can be used in parts or as wholes. Some years ago Meltzer directed attention to what he called the "factor of safety in the animal economy," by pointing out certain facts which had long been known, such as the fact that an individual might be able to live with only one half of one kidney. In mechanical operations, such as bridge building, the factor of safety is from twenty-five to fifty per cent., the engineer making an extra allowance for possible extra loads or strains. In our physiological organs the factor of safety is much greater, as indicated in the example of the kidney, where the safety factor is nearly three hundred per cent. The factor of safety in the brain has not been duly considered, but it may well be that this factor is as great as in any of our other necessary bodily mechanisms. The results of reëducation indicate that there is some extra-cortical material which may be utilized when cortical parts are destroyed or are made functionally inoperative.

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RARE RESEARCH MATERIAL

Recent scientific papers and other data personal and general have suggested to me that researchers, and especially those in the various psycho-biologic fields, should have at their command some agency by which unusual "material" of whatever sort might be made more fitly and more widely available for study. One thinks off-hand, for examples, of unusual blood-pressures; of accident-results perhaps never again to be duplicated, and of conditions of much interest, due to uncommon surgery; of multiple personalities; of cases of bradycardia; somnambulists; hysterics; aphasics; variously skilled persons; of cases of congenital double cataract, both before and after couching; uncommon visual phenomena of many kinds from the kinesthetically expert blindman to unilateral or mixed color-blindness; of internal-ear phenomena; hyperexpert sense-development such as that of smell in Helen Keller, etc.; of open skulls such as Shepard has so usefully employed; of uncommon idiots; of quite numberless varieties of abnormality proper in any scientific biologic direction so frequent in the medical journals and in the treatises on teratism, and so potentially and uniquely useful to science oftentimes, yet so entirely hidden from view and experimental use behind the thick veil of space and time and circumstance.

Therefore I suggest the establishment, by some adequate body, of a sort of *uncommercial registration-bureau*, coöperative in method, to which all and sundry advanced students of any phase of the science of life would habitually briefly report rare or otherwise especially useful research-material; learn where it might be employed; under what conditions; and so on, *pro re nata.*

This agency of scientific coöperation might be a very simple affair so far as business-system is concerned and therefore inexpensive to carry on, and yet be of quite surprising value in the furtherance of psychological, physiological, educational, and general institutional research.

And it is at least to me plain enough that one of the most formidable handicaps to present advance in psychology and in physiology and their congeners, is that the greater number of their devotees, often of the most progressive intelligence, fail to see how much each science has for the use of the other, and wholly ignore the often quite invaluable offerings which *derangements* and *abnormalities* of mind and body, make for comparison and study. It is quite as if a diseased mind or a sick or deformed body were a

geological phenomenon or anything else at all rather than usefully psychological or physiological in the realest sense. But this is only one aspect of the difficulty which the proposed uncommercial registration perhaps would help to solve.

Unusual, even unique, material, and that in great variety, would often prove to be readily available for employment in research, and frequently to the considerable advantage of each party concerned. In some cases loose academic relationship might be set up (like that of the uniquely skilled Blaschkas at Harvard, for example), or even after the now decadent manner by which football "stars" are given (temporary) location in some college constellation. The appreciation and recognition that rare natural phenomena often have great general research-value, is the main thing; the precise means by which they may be made practically available to the right experimenter and observer, would readily work itself out at opportunity.

George V. N. Dearborn

Cambridge, Massachusetts

BOOKS RECEIVED

Hall, G. Stanley. *Jesus, the Christ, in the Light of Psychology.* New York: Doubleday, Page, 1917. Pp. xix+733. 2 vols. $7.50.

Forbes, W. E. *Cycles of Personal Belief.* Boston: Houghton, Mifflin, 1917. Pp. vi+149. $1.25.

Bjerre, P. *The History and Practice of Psychoanalysis.* (Trans. by E. N. Burrow.) Boston: Badger, 1917. Pp. 294. $3.00.

Ferenczi, S. *Contributions to Psycho-analysis.* (Trans. by E. Jones.) Boston: Badger, 1916. Pp. iv+288.

Peters, W. *Ueber Vererbung Psychischer Fähigkeiten.* Leipzig: Teubner, 1916. Pp. 382. (*This is the book confiscated by the British Censor as contraband of war.*—Ed.)

Lay, W. *Man's Unconscious Conflict.* New York: Dodd, Mead, 1917. Pp. 318. $1.50.

NOTES AND NEWS

The present number of the Bulletin, dealing with physiological psychology, has been prepared under the editorial supervision of Professor R. P. Angier, of Yale University.

Dr. A. H. Sutherland, at present instructor in psychology at Yale University, has accepted a position as psychologist in the public school system of Los Angeles.

Dr. C. E. Ferree, of Bryn Mawr College, has been promoted to a professorship in experimental psychology.

Dr. George R. Wells, associate professor of psychology in Oberlin College, has been appointed to a new professorship of psychology in the Ohio Weslyan University, and will assume his duties in September. A psychological laboratory, housed in a separate building, has been provided and is being equipped at the latter institution.

The University of Iowa plans to begin work on child welfare in the summer. The legislature of the state has appropriated $25,000 a year for the work, which will include the investigation of methods of applying psychology to the development of the child.

At a special meeting of the Council of the American Psychological Association it was voted that committees be organized to deal with the relations of psychological methods and information to military activities. The committees with their chairmen are as follows:

(1) General psychological committee of the National Research Council. Chairman and member of the Research Council, Robert M. Yerkes, Harvard University.

(2) Committee on psychological literature relating to military affairs. Chariman, Madison Bentley, University of Illinois.

(3) Committee on the psychological examining of recruits. Chairman, Robert M. Yerkes, Harvard University.

(4) Committee on the selection of men for tasks requiring special skill. Chairman, E. L. Thorndike, Teachers College, Columbia University.

(5) Committee on psychological problems of aviation, including the examination of aviators. Chairman, H. E. Burtt, Harvard University.

(6) Committee on psychological problems of incapacity, especially those of shock and re-education. Chairman, Shepherd Ivory Franz, Government Hospital for the Insane.

(7) Committee on the psychological aspects of vocational advice and training. Chairman, John B. Watson, Johns Hopkins University.

(8) Committee on recreation in the army and navy. Chairman, George A. Coe, Union Theological Seminary.

(9) Committee on pedagogical and psychological problems of military training and discipline. Chairman, Charles H. Judd, University of Chicago.

(10) Committee on problems of motivation in connection with military service. Chairman, Walter D. Scott, Northwestern University.

(11) Committee on problems of emotional stability, fear, self-control, etc. Chairman, Robert S. Woodworth, Columbia University.

(12) Committee on acoustic problems of military significance. Chairman, Carl E. Seashore, University of Iowa.

(13) Committee on visual problems of military importance. Chairman, Raymond Dodge, Wesleyan University.

The chairmen of these committees will welcome pertinent suggestions and offers of assistance in the different lines covered by the topics.

The Southern Society for Philosophy and Psychology held its twelfth annual meeting on April 12th and 13th, 1917, at Randolph Macon Woman's College, Lynchburg, Va. It was voted to extend the scope of the Society so as to include "Experimental Education," and to hold the next meeting at Peabody College for Teachers, Nashville, Tenn. The following officers were elected: President, Prof. E. K. Strong, Jr., Peabody College, Nashville; Vice-President, Dr. T. V. Moore, Catholic University of America, Washington, D. C.; and Secretary-Treasurer, Prof. W. H. Chase, University of North Carolina. The newly elected members of the Council are: Dr. Tom A. Williams, Washington, D. C., Prof. E. B. Crooks, Randolph Macon, Lynchburg, Va., and Prof. Knight Dunlap of Johns Hopkins University.

PUBLISHERS' NOTICE

Owing to the greatly increased cost of production we are compelled to raise the price of our publications. Beginning July 1, 1917, the subscription to the Review and Bulletin will be $6 and to the Journal $3.25, with other rates corresponding. The complete list will be found on the inside cover page.

Psychological Review Company